What is claimed is:

1. A vehicle running state estimation method comprising the steps of:

detecting the vibration level of a portion below the spring of a running vehicle; and

estimating at least one of the condition of a road surface on which the vehicle is running and the running state of each tire based on the detected vibration level to estimate the running state of the vehicle.

2. The vehicle running state estimation method according to claim 1, wherein the waveform of time changes in the vibration level is detected and the condition of a road surface on which the vehicle is running is estimated from a vibration level at a predetermined position of this waveform or for a predetermined time range.

3. The vehicle running state estimation method according to claim 1, wherein the frequency of the detected vibration level is analyzed to calculate a vibration level at a predetermined frequency band and the condition of a road surface on which the vehicle is running is estimated from the calculated vibration level.

4. The vehicle running state estimation method

according to claim 1, wherein the frequency of the above detected vibration level is analyzed, at least two vibration levels at different frequency bands are calculated, an operation is carried out on the above calculated vibration levels, and the condition of a road surface on which the vehicle is running is estimated from the computed value.

5. The vehicle running state estimation method according to claim 1, wherein the vibration levels of at least two points of a portion below the spring of a running vehicle are detected to calculate the vibration transmission level of the portion below the spring of the vehicle, and the condition of a road surface on which the vehicle is running is estimated from the calculated vibration transmission level.

6. A vehicle running state estimation apparatus comprising:

means of detecting the vibration level of a portion below the spring of a running vehicle;

means of computing the waveform of time changes in the vibration level; and

road surface condition estimation means for estimating the condition of a road surface on which the vehicle is running from a vibration level at a predetermined position of the waveform or for a

predetermined time range.

7. The vehicle running state estimation apparatus according to claim 6 which further comprises means of calculating the vibration level of at least one of a tire leading edge portion, tire ground contact portion and tire trailing edge portion of the waveform.

8. A vehicle running state estimation apparatus comprising:

means of detecting the vibration level of a portion below the spring of a running vehicle;

means of calculating a vibration level at a predetermined frequency band by analyzing the frequency of the detected vibration level; and

road surface condition estimation means for estimating the condition of a road surface on which the vehicle is running from the calculated vibration level.

9. A vehicle running state estimation apparatus comprising:

means of detecting the vibration level of a portion below the spring of a running vehicle; and

road surface condition estimation means for estimating the condition of a road surface on which the vehicle is running from a value obtained by carrying out an operation on at least two vibration levels at

different frequency bands by analyzing the frequency of the above detected vibration level.

10. A vehicle running state estimation apparatus comprising:

means of detecting the vibration levels of at least two points of a portion below the spring of a running vehicle;

means of calculating a vibration transmission level at a predetermined frequency band between the at least two of the vibration detection points; and

road surface condition estimation means for estimating the condition of a road surface on which the vehicle is running from the calculated vibration transmission level.

11. The vehicle running state estimation apparatus according to claim 10, wherein a vibration buffer member is interposed between the at least two vibration detection points.

12. The vehicle running state estimation apparatus according to any one of claims 8 to 11, wherein the relationship between road surface friction coefficient μ obtained from the braking distances of a vehicle under various road conditions at different speeds and the vibration level at a predetermined frequency band, the

computed value of vibration level or vibration transmission level is obtained previously and the road surface friction coefficient μ at the time of running is estimated based on the relationship.

13. The vehicle running state estimation apparatus according to any one of claims 8 to 12, wherein the frequency band is a band including the frequency of natural vibration of a tire tread land portion.

14. The vehicle running state estimation apparatus according to any one of claims 8 to 13, wherein a threshold value is set for the vibration level and the surface of a road is estimated to be in a low friction condition when the calculated vibration level exceeds the threshold value.

15. The vehicle running state estimation apparatus according to claim 14, wherein the threshold value can be changed.

16. The vehicle running state estimation apparatus according to any one of claims 6 to 15 which further comprises vehicle speed detection means to estimate the condition of a road surface based on vehicle speed.

17. A vehicle running state estimation apparatus

comprising the vehicle running state estimation apparatus of any one of claims 6 to 16, means of judging the slipperiness of a road surface based on the condition of the road surface estimated by the road surface condition estimation means and warning means for giving a warning when it is judged that the condition of the road surface is slippery.

18. The vehicle running state estimation apparatus according to claim 17 which further comprises vehicle speed detection means to change decision on the slipperiness of a road surface and warning level based on vehicle speed.

19. A vehicle running state estimation apparatus comprising:

means of detecting the vibration level of a portion below the spring of a running vehicle;

means of estimating the air pressure of each tire by calculating the frequency of natural vibration of the tire from a vibration level at a frequency band of 200 Hz or less of the detected vibration level; and

tire running state estimation means for estimating the condition of each tire while running from the estimated air pressure of the tire.

20. The vehicle running state estimation apparatus

according to claim 19 which further comprises tire pressure monitoring means for monitoring the pressure of each tire while running using the estimated air pressure of the tire.

21. The vehicle running state estimation apparatus according to claim 20 which further comprises warning means for warning a passenger of a reduction in the pressure of the tire when the air pressure monitored by the tire pressure monitoring means falls below a predetermined value.

22. A vehicle running state estimation apparatus comprising:

means of detecting the vibration level of a portion below the spring of a running vehicle;

tire revolution speed detection means;

tire running state estimation means for estimating the state of each tire while running by calculating the average value of vibration level changing by the revolution speed of the tire at a frequency band of 100 Hz or less of the detected vibration level; and

tire trouble detection means for judging that the tire is abnormal when the calculated average value of vibration level exceeds a preset reference value.

23. The vehicle running state estimation apparatus according to claim 22, wherein the reference value is set to a range of 1.2 to 5 times the vibration level at a reference decision frequency Fn when the vehicle runs at a predetermined speed V while the tire is not abnormal:

reference decision frequency $Fn = n \times V/(2\pi r)$

wherein r is the rolling radius of the tire, and n is 1, 2, 3, ...

24. The vehicle running state estimation apparatus according to claim 23, wherein the reference value can be changed.

25. The vehicle running state estimation apparatus according to any one of claims 6 to 24 which further comprises a transmitter for transmitting the output of the vibration detection means for calculating a time change in vibration level or a vibration level at a predetermined frequency band.

26. The vehicle running state estimation apparatus according to any one of claims 6 to 25 further comprising a power generating unit which is mounted to a tire wheel, generates power by the rolling of each tire and supplies power for driving the vibration detection means or power for amplifying the output of

the vibration detection means.

27. A vehicle control apparatus comprising vehicle control means for controlling the running state of a vehicle based on the condition of a road surface estimated by the vehicle running state estimation apparatus of any one of claims 6 to 26 and/or the running state of each tire.

28. The vehicle control apparatus according to claim 27 which comprises vehicle speed detection means to control the running state of a vehicle based on vehicle speed.

29. The vehicle control apparatus according to claim 27 or 28, wherein the vehicle control means controls the locked state of each wheel.

30. The vehicle control apparatus according to claim 27 or 28, wherein the vehicle control means controls the attitude of a vehicle.

31. The vehicle control apparatus according to claim 27 or 28, wherein the vehicle control means controls the air pressure of each tire.

32. The vehicle control apparatus according to claim

27 or 28, wherein the vehicle control means controls the idling state of each wheel.

33. The vehicle control apparatus according to claim 27 or 28, wherein the vehicle control means changes the inter-vehicle distance set value of an automatic driving system.

34. A tire wheel comprising the vehicle running state estimation apparatus for estimating the running state of a vehicle by detecting the vibration level of a portion below the spring of a running vehicle as set forth in claims 6 to 26 and a power generating unit for generating power by the rolling of each tire and supplying power to the vehicle running state estimation apparatus.

35. The tire wheel according to claim 34, wherein the vehicle running state estimation apparatus is mounted to the tire wheel.

36. The tire wheel according to claim 34 or 35, wherein the power generating unit comprises a rotor magnetized and rotated by the rolling of each tire, a stator made from a high magnetic permeability material and adjacent to the rotor and a power generating coil installed within a magnetic circuit including the rotor and the

stator.

37. The tire wheel according to claim 36, wherein the power generating unit comprises means of accumulating electromotive force generated in the power generating coil.

38. The tire wheel according to claim 36 or 37, wherein the rotor is turned by rotating an unbalance weight the gravity center of the rotary cone of which is eccentric to a rotary shaft by the rolling of each tire.

39. The tire wheel according to claim 36 or 37, wherein an air stream generated by the rolling of each tire is introduced into the power generating unit and the rotor is turned by the introduced air stream.